

should filter out injurious rays, &c., living organisms could hardly endure the solar light.

Pringsheim operated on chlorophyll tissues. By means of a lens and a heliostat he concentrated upon them sunlight, from which by suitable media he had sifted out the heat rays. In a few minutes the green colouring matter was destroyed, the protoplasmic circulation arrested, the protoplasm disorganised, and the cell flaccid and inert. He found, as we had found, that the more refrangible rays were the most powerful, and he, too, concluded that he was dealing with an oxidation, for in an atmosphere of hydrogen or of carbonic acid these destructive results no longer ensued.

The experiments of Siemens\* and D  h  rain   also demonstrate both the destructive influence of the electric light on vegetation and the protective effect of a glass screen.

[NOTE.—According to an abstract in “Journal of Science,” 3rd ser., vol. vii, p. 594, M. Duclaux has since published the results of his observations on six species of *micrococci*, apparently of pathogenic kind.  ]

Forty days of insolation (May 4—June 13) proved sufficient to kill and less to attenuate these germs in the moist state. In a desiccated condition eight days (May 26—June 3) proved fatal; in July none resisted three days’ exposure at a south window which received the sun only from nine to one o’clock each day, and where the temperature did not exceed 102   F. (39   C.). Fifteen days of July sun destroyed the micrococci in the moist state. He had not in these experiments eliminated any partial influence of temperature. January 4, 1886.—A. H. D.]

II. “Notes upon the Straining of Ships caused by Rolling.” By FRANCIS ELGAR, LL.D., F.R.S.E., Professor of Naval Architecture and Marine Engineering in the University of Glasgow. Communicated by Sir E. J. REED, F.R.S. Received December 28, 1885.

(Abstract.)

It does not appear that any serious attempt has yet been made to investigate the amounts, or even the nature, of the principal straining

\* “Rep. Brit. Assoc.,” 1881.

   “Journ. Chem. Soc.” (Abst.), Jan., 1883. Considerations of time and space prevent me from noticing many other observations of interest in connexion with this subject; *e.g.*, of Engelmann on *Pelomyxa* (“Arch. f. Phys.,” xix, 1879) and on *B. photometricum* (“J. Roy. Mier. Soc.,” Abst., 1882-2), or of Stahl, “On the Arrangement of Chlorophyll Bodies in Plant-Cells” (“Bot. Zeit.,” 1880).

   “Comptes rendus,” 1885.

actions which the rolling of a ship brings into play, or of the effect of those straining actions upon the material of which the hull is composed. Various writers, from Bouguer in 1746, down to Professor Macquorne Rankine in 1866, and Sir E. J. Reed in 1871, have discussed the straining actions that are caused by longitudinal racking and bending when a vessel is floating in statical equilibrium. Sir E. J. Reed elaborately investigated the subject in a paper contained in the "Philosophical Transactions of the Royal Society" for 1871, and gave examples of the amounts and distribution of the stresses caused by such straining actions in several typical ships of Her Majesty's Navy. Mr. W. John supplemented this by a paper on the strength of iron ships, read before the Institution of Naval Architects in 1874, in which similar results were given for various classes of vessels in the mercantile marine.

The later investigations of these longitudinal straining actions apply not only to the case of a ship floating in equilibrium in still water, but also to cases in which she is (1) in instantaneous statical equilibrium across the crest of a wave; and (2) in instantaneous statical equilibrium across the hollow of a wave—the wave-length being equal to the length of the ship.

Cases frequently occur which show that the maximum stresses of the material of a ship's hull are not in proportion to the results obtained by the ordinary calculations; and that certain deductions that have been drawn from those results are by no means sound. For instance, it is said to follow from the analogy between the longitudinal bending action upon a ship afloat and that upon a loaded girder, that there is little or no stress exerted upon that portion of a ship's plating which is in the vicinity of the neutral axis for the upright position; and the inference has been drawn that, subject to the consideration of the sides being occasionally brought, in some degree, into the positions of flanges of a girder by large inclinations, the thickness of the material may be decreased with advantage near the neutral axis. Now it cannot be shown that the plating which is in the vicinity of the neutral axis when the ship is upright, is ever brought into such a position by the rolling of a vessel as to be much affected by mere longitudinal bending.

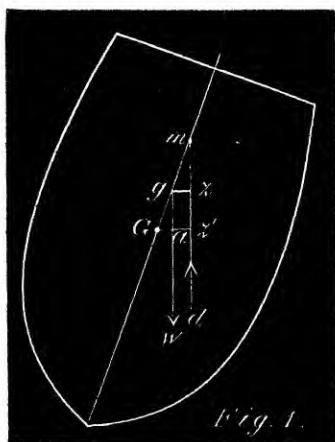
The reason commonly given for not decreasing considerably the thickness of side plating in the vicinity of the upright neutral axis, viz., that when a ship is in an inclined position, this plating may be so placed as to offer the greatest resistance to longitudinal bending is seen, if the matter be properly considered, to be obviously unsatisfactory.

Other propositions respecting the relative distribution of stress in various parts of the structure have been deduced from considerations and assumptions upon which the ordinary calculations of

longitudinal strength are based ; and rules have, in consequence, been proposed for regulating the strength of the principal component parts of ships' hulls. It is only necessary here to say, that many of these deductions, like the one already noticed, are unsound, and are not consistent with the effects that may be observed of straining action at sea.

A considerable experience at sea, where the writer has closely observed the effects of straining action caused by twisting moments, and a further experience in investigating the stresses to which the various portions of ships' hulls are subjected according to the theories referred to, and in comparing the results so obtained with the visible evidences of straining action, have convinced him that the stresses caused by twisting moments are much greater than is generally supposed, and that no rules for regulating the strength of ships can be satisfactory if based upon hypotheses that exclude all practical consideration of twisting moments.

The straining action which will be considered in this paper is that caused by the twisting moments which operate when a ship rolls from side to side ; and which are caused by differences in the longitudinal distribution of the moments of the forces that cause rotation, and those which resist rotation.



Let a unit of length included between two transverse vertical sections be taken at any point in a ship's length, and let fig. 1 be the section of the ship at that point. The section may be taken as uniform over this short length. The energy of rotation of this unit of length will be  $\frac{\omega^2}{2g}wh^3$  ; where  $\omega$  is the angular velocity in the upright

position,  $w$  is the weight of the unit of length and its contents, and  $\frac{w}{g}k^2$  is the moment of inertia of the unit of length about the axis of rotation.

In order to form an equation of energy and work, we require to assume an axis of rotation for the ship; and the assumption here made is, that the axis of rotation is a principal longitudinal axis through the centre of gravity  $G$  of the whole ship and her contents. A ship's axis of rotation is not, in reality, fixed; but that may for the present be disregarded. The important point in connexion with it is that, whatever position the instantaneous axis may occupy at any given moment, it is the axis about which each unit of length of the ship is then rotating, with the same angular velocity. This condition follows from the rigidity of the ship, or rather from the structure being so nearly rigid that any motion of one part relatively to another, about the axis of rotation, is so small that it may be neglected.

When the unit of length shown in section in fig. 1 is inclined to an angle  $\theta$  from the upright, the principal forces which act upon it are—first, the weight  $w$  of every part of the ship and her contents that is contained in this length, acting vertically downwards through its centre of gravity  $g$ ; and, secondly, the weight of the volume of displacement  $d$  for the unit of length under consideration, acting vertically upwards in a line,  $dm$ , through its centre. These forces are equivalent to the couple  $d \times gz$ , and a vertical force at  $g$  equal to  $w - d$ .

Let  $G$  be the point in which the axis of rotation through the centre of gravity of the ship intersects the section in fig. 1. Then the moment which resists the inclination of the section at any angle  $\theta$  will be the resultant of the two couples  $d \times gz$  and  $-(w - d)Ga$ . Let  $w - d = \delta$ . The work done in inclining the unit of length in fig. 1 to the angle of inclination  $\Theta$  will be  $d \int_0^\Theta gz d\theta - \delta \int_0^\Theta Gad\theta$ . If a curve be constructed with the length of the ship for an abscissa line, and the values of  $d \int_0^\Theta gz d\theta - \delta \int_0^\Theta Gad\theta$  for ordinates—these values being set off at points in the length to which the sections for which they are calculated correspond—it will represent the longitudinal distribution of the work done in opposition to the action of the righting moments. The base line in fig. 2 represents the length of the ship. Suppose the first ordinate to be at the plane of division for which the section of the ship is as shown at fig. 1, we then require to determine the value of  $d \int_0^\Theta gz d\theta - \delta \int_0^\Theta Gad\theta$ , at this section, which may be readily done.



may be readily determined ; and a method of doing this is described at length in the paper.

The results given by the investigations described apply only to ships rolling from side to side in still water, assuming that the water offers no resistance to rolling motion. It is obvious, however, that the twisting moments thus obtained must often be greatly exceeded when a vessel is rolling and pitching while lying or moving across a series of long ocean waves. In these circumstances the bow or stern frequently has so little immersion that the righting moment acting upon a portion of one end is momentarily very small, and almost the whole of the energy of rotation is applied to the production of twisting moments. The resistance of the water would also often increase the twisting moments.

It now remains to be seen what can be done in the way of determining the stresses upon the hull which are caused by the twisting moments. We can learn something of the nature and distribution of those stresses ; but, at present, their amounts cannot be calculated with any reliable approach to accuracy. Experiments are required upon the torsion of thin shells of various prismatic forms in order to furnish the requisite data for dealing with so complicated a case as that of a ship's hull. The difficulty of obtaining such data is very great ; but pending the time when it is to be hoped this want will be supplied, it may be useful to draw attention to some of the general considerations which affect the twisting moments and the distribution of the twisting strains and stresses over a ship's hull ; and to the bearing which these have upon the important practical problems that relate to the structural strength of ships.

The best data available for guidance in judging of the distribution of strain and stress due to twisting over the structure of a ship are to be found in M. de St. Venant's investigations of the torsion of prisms.\* These investigations assist us to form a general idea of the manner in which a ship's structure may be strained by twisting ; and they also indicate the nature of the experiments that are necessary to furnish data for more exact investigations. The mean amount of the twisting moment upon a ship's hull at any transverse plane of division, and also the maximum twisting moment, may be obtained by the method described in the present paper. The torsional strength of the hull at that section will depend (1) upon the thin iron or steel shell of which the structure consists, being stiffened internally so as to effectually resist change of form ; and (2) upon the ratio which the strength of a section of such form, when so stiffened, bears to that of a

\* "Mémoires présentés par divers Savants à l'Académie des Sciences de l'Institut Impérial de France," tome quatorzième, 1856. "Mémoire sur la Torsion de Prismes, &c." Par M. de Saint-Venant," pp. 233-560. Also Thomson and Tait's "Natural Philosophy," vol. i, Part II, secs. 699-710.

hollow circular cylinder of the same thickness and the same sectional area. Experiments upon the torsional strength of hollow prisms of various forms, having the same sectional area and thickness of shell, can alone determine the latter point; while, at the same time, such experiments would serve the further purpose of showing how the condition above referred to—that the shell shall be stiffened internally so as to effectually resist change of form—can best be complied with.

The distribution of the torsional stresses over the transverse section of a ship's hull is obviously different from the distribution of the stresses due to longitudinal bending. The parts subjected to greatest stress by twisting are those which are near to the centre of gravity of the transverse section; and they are the side plating near the neutral axis of longitudinal bending in the upright position and the middle portions of the plating of the decks. Those parts of the hull which are usually made the strongest, viz., the strakes of side and bottom plating that are farthest from the neutral axis, and the upper deck stringer plate, are those which are least affected by twisting. It is probably owing, in great measure, to the straining action caused by twisting, that experience has proved it to be necessary to make the outside plating of a ship of nearly uniform thickness over the whole section; and it cannot be because of the reason sometimes given, that the plating in the vicinity of the neutral axis when a ship is upright is often brought by rolling into positions in which it is greatly strained by longitudinal bending.

The importance of many of the structural arrangements of ships that are described in the present paper, which practical experience has shown to be necessary, may be understood from these considerations; and it will also be seen that no rules for regulating the strength of ships are likely to be satisfactory if based, as is often done, upon the hypothesis that the straining actions caused by longitudinal bending are so much more important than all others that it is sufficient to regard them alone.

III. "Proteid Substances in Latex." By J. R. GREEN, B.Sc., B.A., Demonstrator of Physiology in the University of Cambridge. Communicated by W. T. THISELTON DYER, C.M.G., F.R.S., Director of Royal Gardens, Kew. Received January 4, 1886.

In the study of the metabolism of plants, the nature of the products resulting therefrom, and the different forms assumed by these bodies during the changes involved, attention has been chiefly



